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(54) Aluminium bronze alloys

(57) A non-heat treatable Mn-Al-multicomponent bronze alloy for forming and deforming tools, more especially drawing, bending and pressure casting tools used in the metal and plastics material working industries has the chemical composition by weight of
Mn 9.0—11.0%, Zn 5.5—10.0%, Al 7.5—9.0%, Fe 2.0—4.0%, Ni 1.5—3.0%, C 0.03—0.20% and the remainder Cu.

The mechanical properties of this alloy are

ultimate breaking strength:
700—850 MPa

hardness:
200—300 HB

elongation at rupture:
10—3%

thermal conductivity:
0.2 cal/degr. sec. m.

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SPECIFICATION
Aluminium bronze

The invention relates to a Mn—Al-multicomponent bronze for forming and deforming tools, more especially for drawing, bending and pressure casting tools.

During sheet-metal forming, friction arises on the actively acting elements, which leads to high wear. These wear phenomena can be reduced by lubricants, sheet-metal coating, inserting foils and using non-ferrous alloys for the active tool elements. During stainless sheet-metal forming, additional difficulties arise in that, when use is made of known tool steels, there come about cold shuts on the actively acting elements of the forming tools. These cold shuts lead to scoring on the formed parts and thus to a constant deterioration in quality, which may even lead to rejects.

It has already been proposed to use, for the elimination of cold shuts, aluminium bronzes composed of

8.5—11.5 % Al
— 7.0 % Fe
— 1.0 % Mn
— 2.5 % Si
— 6.5 % Ni
the remainder Cu or
8.0 % Al
13.0 % Mn
2.0 % Fe
2.5 % Ni
the remainder Cu,

which have however the disadvantage that they are very hard and brittle and are therefore difficult to work mechanically. Furthermore, this alloy necessitates a heat treatment in order to ensure its workability. Another disadvantage is the fact that only small outputs can be realised with this alloy. In order to eliminate these disadvantages, it has also been proposed to use a Cu—Ni—Mn alloy containing

20 % Ni and 20 % Mn
or 30 % Ni and 30 % Mn.

The non-ferrous alloys Cu—Ni—Mn 20/20 and
Cu—Ni—Mn 30/30

are relatively easy to work mechanically but also have to be subsequently heat-treated prior to being used as an active tool element, which makes a dimensional or geometrical change of these parts unavoidable.

It is possible to produce formed parts of high quality by means of these alloys, but the outputs obtained are not satisfactory. The manufacture of the active parts requires an extensive cutting process since the basic material can only be made available as wrought material in the form of slabs or semi-finished products.

It is possible to produce formed parts of good quality with the known aluminium bronzes having an Al content of more than 9 %, but the outputs obtainable are not satisfactory. Furthermore, due to their high strength, the active tool elements can only be machined by means of special machines and tools.

There has also been proposed a copper casting alloy composed of

9.0—13.0 % MN
7.1—12.0 % Zn

1.0— 3.0 % Fe

— 4.0 % Ni

4.5— 7.0 % Al

and at least 65.0 % Cu.

This alloy does allow normal machining but, due to its low strength and minimal hardness, it is not possible to obtain satisfactory outputs therewith. This alloy is particularly suitable for mechanically and chemically stressed parts, such as propellers of ships, components of ships and parts of pumps.

A particularly troublesome element for attaining the necessary high degree of toughness of this alloy is the carbon, which is therefore limited to 0.03 %.

As opposed to bending and drawing tools, special forming tools used in deforming engineering are mainly made from Al materials. This material has unfavourable wear characteristics which allow only relatively short tool lives. Increased costs as well as additional production capacities for the production of spare tools have to be taken into account for this reason.

For the mentioned field of application, there is also known the aluminium-multicomponent bronze "Inoxyda" (Technische Rundschau Sulzer 3/1969, p. 117 etc.). This alloy has a high degree of strength and hardness, which is brought about with the following chemical composition:—

0.5— 2.0 % Mn

— 5.0 % Fe

— 5.0 % Ni

9.0—15.0 % Al

the remainder Cu.

Due to the fairly high proportion of the κ-phase in the structure, the elongation of this alloy for tools is only approximately 2 %. The strength is high and the resistance to cavitation is better than in stainless 18/8-CrNi steels and the 13 % Cr steels. The alloy also has a good sliding and wear-resistance behaviour.

However, as a disadvantage it is found that the high Al content leads altogether to a high degree of hardness or causes hard places in the casting, which leads to an increased expenditure relating to treatment (additional soft annealing). Furthermore, the casting characteristics of this alloy are not favourable.

In the Mn—Al-multicomponent bronzes, it has turned out again and again that by harmful additives such as carbon, phosphorus and sulphur, the toughness falls below technically acceptable limits.

In addition to a certain toughness, a high degree of strength is necessary for deforming tools so as to obtain high outputs. The relatively expensive scarce element tin increases, up to an addition of 1 %, the strength of the alloy of this kind without substantially reducing the elongation. But the high price and the scarcity thereof prohibit the extensive use of this element.

It is the aim of the invention to eliminate the mentioned deficiencies and disadvantages of the known alloys by the use of a suitable material, that is to say, above all, to improve the toughness, the casting characteristic and the workability, such as an increased machinability without additional soft-annealing of the tools. Likewise, a subsequent heat-treatment of the finish-machined tools is to be avoided so as to prevent any dimensional or geometrical changes. Furthermore, the alloy should be provided so that higher outputs can be realised without causing a restriction with respect to the quality of the formed parts or die-castings. For this purpose, the wear-resistant behaviour must also be improved by a high degree of strength, hardness and a relatively high degree of toughness of the alloy.

It is the object of the invention to develop an alloy for forming and deforming production means, more especially for drawing, bending and pressure casting tools, on the basis of a Mn—Al-multicomponent bronze which mainly excludes the following disadvantages:—

— A high machining expenditure by working the formed parts from semi-finished products
— Difficult machinability of Al alloys having a proportion of more than 9 % Al or high proportions of Ni and Mn
— A lower output due to minimal hardness and strength at Al proportions of less than 7 %
— Cold shuts on the active elements during the production process
— Scoring on the formed goods
— The necessity of a heat-treatment of the active elements
— Elongation values which are too low (≅2 %)

— Poor melting and casting characteristics
— Too large a proportion of the κ-phase in the structure
— Too large a proportion of Cu in the composition.

In particular, there are to be achieved with the alloy:—
— An improved castability
— Good sliding characteristics
— A high resistance to wear
— A good thermal conductivity
— A high output.

According to the invention, the problem is solved in that the alloy is a composition of

9.0 —11.0 % Mn

5.5 —10.0 % Zn

2.0 — 4.0 % Fe

1.5 — 3.0 % Ni

7.5 — 9.0 % Al

0.03— 0.20 % C

the remainder Cu.

Related to the proposed composition of the alloy, it is found that the carbon is incorporated in the crystalline lattice of the alloy as an interstitial solid solution and thus increases the bracing of the lattice without, however, considerably reducing the toughness by its absolute limitation. It promotes the martensitic structure formation and leads to an increase in the resistance to breakage and wear. The increased C content furthermore has the effect that a less pure, and thus cheaper, starting material can be used.

The solution according to the invention will hereinafter be once more illustrated with the aid of several design variants.

Alloy element	Variants I mainly for pressure casting tools (%)	II mainly for bending tools (%)	III mainly for deep drawing tools (%)
Mn	11.0	9.5	10.5
Zn	10.0	8.2	9.0
Fe	3.5	2.2	3.0
Ni	2.0	1.6	2.0
Al	7.5	7.7	8.5
C	0.08	0.2	0.1
Cu	remainder	remainder	remainder

Mechanical characteristics (measured on sand casting samples)	Variants I mainly for pressure casting tools (%)	 II mainly for bending tools (%)	 III mainly for deep drawing tools (%)
Ultimate breaking strength MPa	700—720	740—770	780—850
Elongation at rupture %	10—8	6—4	8—3
Hardness HB	200—220	210—240	200—300
Thermal conductivity	0.2 cal/degr. sec. m	0.2 cal/degr. sec. m	0.2 cal/degr. sec. m

Due to use being made of the proposed Mn—Al-multicomponent bronze for drawing, bending and pressure casting tools for forming and deforming engineering, the following advantages are provided:—

— Production of tool blanks by the casting method as opposed to working the formed parts from semi-finished products, which requires a great deal of machining

— Machining of the blanks with normal tools and machines is possible

— Elimination of the hitherto necessary heat-treatment of the active parts; avoidance of dimensional or geometrical changes by a subsequent heat-treatment of the active parts

— The possibility of correcting the active parts in order to eliminate slight wear phenomena

— Low-loss metal recovery by means of pure-grade re-melting of active parts no longer needed and of the chips obtained during machining

— A lower proportion of copper in the composition

— Use of an impure and thus cheaper starting material

— Improved melting and casting characteristics of the material

— A lower κ-phase proportion in the structure

— A high degree of toughness (breaking elongation of the material and thus a higher resistance to wear in higher outputs)

— Good sliding characteristics

— Good thermal conductivity

The utilisation of the proposed alloy by way of trial has shown that outputs of more than 300 000 parts can be achieved during the processing of stainless steel formed parts for washing machines.

CLAIMS

1. A Mn—Al-multicomponent bronze for production means used in forming and deforming engineering, more especially for drawing, bending and pressure casting tools, characterised by an alloy containing

	9.0—11.0 % Mn	by weight
	7.5—10.0 % Zn	by weight
	2.0— 4.0 % Fe	by weight
	1.5— 3.0 % Ni	by weight
	7.5— 9.0 % Al	by weight
	0.03— 0.2 % C	by weight
the remainder	Cu.	

2. A Mn—Al-multicomponent bronze for production means substantially as described herein.

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